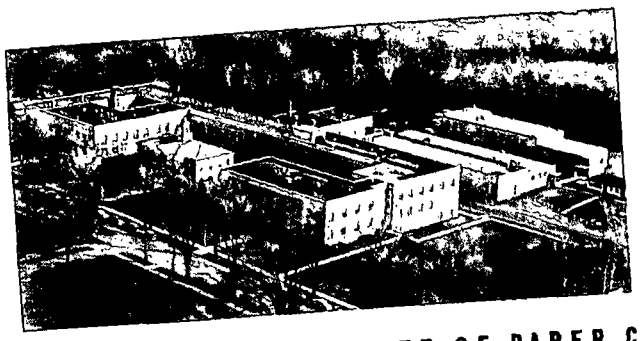

THE INSTITUTE OF PAPER CHEMISTRY, APPLETON, WISCONSIN

DEVELOPMENT OF AN IMPROVED DIFFUSION BOARD MATERIAL

Project 2256

Report Eighteen

A Monthly Report

to

U. S. ARMY CHEMICAL CENTER PROCUREMENT AGENCY

Report Period: March 29, 1962 to April 28, 1962

July 6, 1962

THE INSTITUTE OF PAPER CHEMISTRY

Appleton, Wisconsin

DEVELOPMENT OF AN IMPROVED DIFFUSION BOARD MATERIAL

Project 2256

Contract No.	DA18-108-405-CML-941
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A Monthly Report

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THE INSTITUTE OF PAPER CHEMISTRY

Appleton, Wisconsin

DEVELOPMENT OF AN IMPROVED DIFFUSION BOARD MATERIAL

SUMMARY

The planned program of laboratory board studies was completed. In this program, studies were conducted to determine the effects of zinc oxide as a stabilizer, varied Aquapel and Kymene additions, and variations in charcoal loading and caliper on the physical and gas life properties of diffusion board. The results from these studies could not be evaluated satisfactorily because the effects of the variables on gas life and sizing were masked by the deleterious effects of some of the pulp constituents. The effect of the pulp was not anticipated since the pulp used was supposedly identical to the pulp used in the Bauer Bros. pilot trials one year ago and the latter pulp performed satisfactorily. Preliminary investigation has indicated that the pulp used this year was not adequately washed. However, the following conclusions were indicated by the data: (1) increased Aquapel additions produced increases in sizing, modulus of rupture, and the wet tensile. (2) Increased Kymene additions produced increases in all the strength properties. (3) Increased charcoal content resulted in some increases in gas life and in diffusivity with decreases in the sizing and strength of the board. (4) Caliper increases produced increases in gas life due to the increased areal charcoal loading and seemed to have little effect on diffusivity. These data did not indicate any basis for deviating from the standardized caliper of three-eighths inch and additions of 25% charcoal, 0.5% Aquapel, and 0.2% Kymene.

Investigations of the effects of pulp on gas life were carried out concurrently with the laboratory board studies. Gross differences in gas life were found between boards formed from the presently available pulp and samples of pulp

obtained one year ago; the critical beds of boards formed from this year's pulp ranged from 4.2 to 4.7 g./100 sq. cm. while those of the board formed from the last year's pulp were 3.6 to 3.8 g./100 sq. cm. Pulps received this year were taken directly from the grinder chest; pulp received last year was washed and dewatered on the machine.

A preliminary production trial was conducted at the Wood Conversion Company in Cloquet, Minnesota on April 17, 1962. Two thousand square feet of board containing 25% charcoal, 0.5% active Aquapel 360, and 0.2% active Kymene 557 based on dry fiber content was produced. The board was dried in a hot air drier using steam coils to heat the air. Fires occurred in the drier at an air temperature setting of 350°F. and recurred after the temperature setting had been reduced to 300°F. As a consequence, a production run of diffusion board scheduled for the first week of May was cancelled pending the outcome of an investigation of the cause of the fires and of the flammability of the board.

Drying studies were begun at the Institute in order to determine the drying conditions under which a board or stack of boards might catch fire. Two tests were made during this reporting period. Thermocoupled stacks of wet boards, three layers thick, were placed in a circulating air oven. In the first test the boards began to burn after 2 hours and 16 minutes exposure at an oven temperature of 350°F. In the second test a stack of wet boards was placed in the oven and exposed to 300°F.; after 8 hours and 46 minutes the boards showed no signs of burning or charring.

LABORATORY BOARD STUDIES

PULP

As indicated in Reports 15 and 17, when work on the project was resumed a series of laboratory trials were initiated to pick the optimum conditions for use in a commercial production run of board. After making trials of laboratory refining, it was discovered that the pulp being used had been prepared by Wood Conversion Company in the laboratory and also that they believed our laboratory Sprout-Waldron would not correlate with the commercial Bauer refiners they planned to use (these laboratory trials had yielded poor strength and sizing). Because of the time required, we were anxious to initiate the mildew testing, and the series of boards with fungicides was made with this laboratory pulp. The rest of the laboratory program was postponed until pulp more representative of that to be used commercially could be obtained. Small samples of pulp at four degrees of refining were furnished by Wood Conversion Company and tested as described in Report 17; one of these (No. 2 slow stock) was selected and then a larger sample comparable to it was obtained and used for the balance of the laboratory program.

The poor gas life reported for the series of fungicide-containing boards made with the laboratory pulp raised a question on the reason for this change, as compared to experience in 1961 prior to suspending work. To check the effects of pulp versus other possible changes such as deterioration in charcoal or other additives, the laboratory schedule was interrupted in order to make a series of sized and unsized boards using the laboratory pulp, the new commercial pulp (original sample of No. 2 slow stock) and the commercial pulp used in the 1961 pilot trial at Bauer Bros. Company. The sized boards were made with 0.5% Aquapel 360 and 0.2% Kymene 557. Samples were submitted for gas life evaluation but

because of the urgency of the program the balance of the planned schedule of laboratory boards was made with No. 2 slow stock before these gas life results were received.

The gas life results shown in Table I indicate that gas life comparable to that obtained before interrupting the program could be obtained by using the pulp left from the 1961 pilot trial but that the newer pulps gave poorer results. Discussion with Wood Conversion Company personnel confirmed that the same type of wood, method and degree of cooking was still being used. However, the 1962 samples had been received at lower consistency than the pilot run material; discussion of this point revealed that the 1961 material had been pumped to a commercial machine through a washer and then dewatered on the machine for shipment. In 1962, because of the smaller quantities and the urgency, samples had been taken directly from the grinder chest, squeezed out by hand, and shipped at consistencies slightly over 20%. This means that, except for the liquor squeezed out in the process of taking the samples, very little of the cooking chemical or soluble components were removed from the pulps. In addition, it appears that it is not unusual to use white water from one of the machines for grinding. As a result, even samples which were indicated as containing no size may have contained rosin and alum, or possibly other materials such as starch, from the machine operations. Since it is known that further washing of the already-washed pilot run pulp improved its performance, it seems probable that lack of washing is a critical factor in the poor performance of the 1962 pulps.

Samples of these pulps were tested for ash and water solubles content and the pH of the hot water extractables was measured. This was done as a step in the process of determining a characteristic of these pulps that might be

correlated with their effects on gas life. The results of the test are given in Table II; the high soluble content and low pH of the No. 2 slow stock is obvious.

TABLE I

GAS LIVES OF BOARDS FORMED FROM VARIOUS WOOD CONVERSION COMPANY PULP STOCKS

Sample 2256-2085-	Pulp	Sizing	Estimated Charcoal Loading, g./100 sq.cm.	CK Life, min.	Critical Bed, g./100 sq.cm.	PS Life, min.
28-1	2085-16-1 No. 2 Slow Stock	No	5.36	32	4.2	27
28-2	No. 2 Slow Stock	Yes	5.19	13	4.7	21
28-3	2085-12 Lab Stock	No	5.97	44	4.3	22
28-4	Lab Stock	Yes	5.16	18	4.4	21
28-5	Bauer Bros. Pilot Run (1961)	No	5.62	53	3.6	31
28-6	Pilot Run (1961)	Yes	5.33	44	3.8	29
PR-3,4-127[a]	Bauer Bros. Pilot Run (1961)	No	6.0	60	3.8	
PR-1,2-127[a]	Bauer Bros. Pilot Run (1961)	Yes	5.75	51	3.8	

[a] Boards formed in laboratory and tested in 1961.

TABLE II

LABORATORY TESTS ON VARIOUS WOOD CONVERSION COMPANY PULP STOCKS

Pulp	Ash, %	Hot Water Solubles, %	pH of Hot Water Extract
2085-16-1 No. 2 Slow Stock	1.90	9.1	5.6
2085-12 - Lab. Refined	0.96	2.9	6.3
Bauer Bros. Pilot Run	4.16	3.2	7.3

STABILIZER

Previous work with USP zinc oxide had indicated that small amounts enhanced the CK life of diffusion board, both initially and over a nominal aging period. It was decided that zinc oxide should be further investigated as a possible board additive, using one of the types of zinc oxide available on a commercial scale. Based on a telephone discussion with Mr. F. C. Schmutz of the New Jersey Zinc Company, one of their grades of zinc oxide, called Kadox 15, was selected because of its high purity (99.7%) and because it is one of their most reactive grades.

Boards, sized with 0.5% additions of active Aquapel 360 and 0.2% additions of active Kymene 557 and incorporating 25% additions of ASC charcoal, were formed with various additions of Kadox zinc oxide ranging from 0.5 to 2.5%. The additions were made to a 4% slurry of pulp in the following order: Aquapel 360, Kymene 557, zinc oxide, and charcoal.

An exception to the order of addition was the last board of the series (31-7) in which the charcoal and zinc oxide were added together as a 25% slurry of the charcoal. Specimens of these boards were tested for gas life, density, and water absorption (Table III). The CK and PS gas life tests did not indicate any gross improvements as the result of the presence of the zinc oxide; the poor gas life activity of the untreated board, however, (see above under Pulp) may have masked the stabilizing effects of the zinc oxide. Zinc oxide additions above the level of 0.5% seemed to have a deleterious effect on water absorption.

TABLE III

EFFECT OF ZINC OXIDE ON DIFFUSION BOARD PROPERTIES
(All boards sized unless noted otherwise)

Sample 2256-2085-	Zinc Oxide Addition, % of o.d. fiber	Caliper, in.	Density, lb./cu.ft.	Water Absorption, 2-Hr. Soak, %	Water Absorption, 24-Hr. Soak, %	Charcoal Loading, g./100 sq.cm.	CK Gas Life, min.	CK Gas Life, Critical Bed, g./100 sq.cm.	PS Gas Life, min.
32-1,2,3	Blank, Sized	0.349	19.42	9.3	22.4	5.51	7	5.25	19
31-1,2	0.5	0.369	19.19	8.3	20.4	5.78	6	5.60	19
31-3,4	1.5	0.356	19.23	13.9	27.4	5.51	6	5.08	17
31-5,6	2.5	0.351	19.34	11.3	24.4	5.46	6	5.28	18
31-7	2.5[a]	0.357	19.19	--	--	5.58	8	5.44	15

[a] Zinc oxide added in charcoal slurry.

SIZING ADDITIONS

The standard size additions used in this block of laboratory work and in much of the previous work have been 0.5% active Aquapel 360 and 0.2% active Kymene 557 on the basis of ovendry fiber. The effects of small variations in these additions were studied by increasing the addition level of one component while maintaining the standard level of the other component. The boards produced for these studies were tested for water absorption, gas life, and strength (Table IV). An increase in the Aquapel addition level resulted in decreased water absorption, an increased modulus of rupture, no change in dry tensile, and a slight increase in wet tensile. Boards made with an increased addition level of Kymene 557 had the best strength properties and had water absorption properties between those of the boards containing 0.5 and 1.0% Aquapel additions. Comparison of the sized and unsized boards indicates some loss in dry strength and a nominal increase in wet strength as a result of the size additions. The gas lives of these boards, as was the case with the boards treated with zinc oxide, were too low to give any indication of the effects of the additives; however, both the PS and CK lives seem to be affected by the presence of Aquapel and Kymene. Sizing, as measured by resistance to water absorption, was not as effective as expected on the basis of previous work (see Fig. 1, Report 16); possibly, the same pulp impurities that cause the drastic losses in gas life interfere with the sizing.

CHARCOAL LOADINGS

Sized boards (0.5% addition of Aquapel 360 and 0.2% addition of Kymene 557) were formed with charcoal additions varying from 25 to 45%. These boards were compared by testing for carbon dioxide diffusivity, water absorption, gas life, and strength. The test results (see Table V), although they are not

TABLE IV

EFFECT OF AQUAPEL 360 AND KYMENE 557 ON DIFFUSION BOARD PROPERTIES
(25% charcoal in no. 2 slow stock)

Sample 2256-2085-	Aquapel 360 Addition, Act. Material, % of o.d. fiber	Kymene 557 Addition, Act. Material, % of o.d. fiber	Caliper, in.	Density, lb./cu. ft.	Water Absorption, 2-Hr.Soak, %	Water Absorption, 24-Hr.Soak, %	Charcoal Loading, g./100 sq.cm.	CK Gas Life, Critical Bed, min.	CK Gas Life, Critical Bed, g./100 sq.cm.	PS Gas Life, min.	Beam Strength, Breaking Load, lb.	Beam Strength, Modulus of Rupture, p.s.i.	Tensile Strength, Dry, p.s.i.	Tensile Strength, Wet 2-Hr.Soak, p.s.i.
30-1,2	Blank	Blank	0.363	19.24	--	--	5.69	13	5.20	22	3.92	291.3	240	25.6
34-1,2[a]	Blank	Blank	0.308	19.56	18.4	33.2	4.90	26	3.92	24	--	--	--	--
32-1,2,3	0.5	0.2	0.349	19.42	9.3	22.4	5.51	7	5.25	19	3.08	186.0	196.3	57.2
32-4,5,6	0.5	0.4	0.341	19.28	8.1	21.0	5.34	6	5.11	17	4.10	315.5	234.5	95.6
32-7,8,9	1.0	0.2	0.342	18.87	7.0	16.0	5.24	4	5.09	16	3.72	270.2	197.7	69.8

[a] The caliper of this board is somewhat below the range for other boards of this series. It is likely that an error was made in weighing of the pulp prior to the make-up of the slurry from which the board was formed. In this case the ratio of charcoal to fiber would be greater than 25%; thus, the test results are of doubtful validity.

TABLE V

EFFECT OF CHARCOAL LOADING ON DIFFUSION BOARD PROPERTIES
(All boards sized unless noted otherwise)

Sample 2256-2085-	Charcoal Addition, % of o.d. Fiber	Caliper, in.	Density, lb./cu.ft.	Carbon Dioxide Diffusivity, sq.cm./sec.x10^{-2}	Water Absorption, 2-Hr.Soak, %	Water Absorption, 24-Hr.Soak, %	Charcoal Loading, g./100 sq.cm.	CK Gas Life, min.	CK Gas Life, Critical Bed, g./100 sq.cm.	PS Gas Life, min.	Beam Strength, Breaking Load, lb.	Beam Strength, Modulus of Rupture, p.s.i.	Tensile Strength, Dry, p.s.i.	Tensile Strength, Wet 2-Hr.Soak, p.s.i.
50-1,2	25(Unsized)	0.363	19.24	2.93	--	--	5.69	13	3.20	22	3.92	291.3	240	25.6
54-1,2[a]	25(Unsized)	0.308	19.56	3.48	18.4	33.2	4.90	26	3.92	24	--	--	--	--
52-1,2,3	25	0.349	19.42		9.3	22.4	5.51	7	3.25	19	3.08	186.0	196.3	57.2
55-1,2,3	35	0.350	19.20	3.10	10.4	22.2	7.14	34	5.86	35	3.12	231.9	192.4	70.5
53-4,5,6	45	0.374	19.44	3.29	8.7	20.1	9.14	91	5.70	50	3.52	209.4	166.4	23.4

[a] See notation "a" Table IV.

completely consistent, indicate that increased charcoal additions result in increased gas life (but critical bed also increases), and at 45% may cause a reduction in dry tensile strength and a gross reduction in wet tensile strength. A trend of increased diffusivity with increased charcoal loading is also indicated by this data.

CALIPER

Boards were formed using varied amounts of pulp (ovendry basis) to produce boards of varied calipers, keeping percentages of additives constant. The boards were tested for carbon dioxide diffusivity and gas life (see Table VI). The diffusivity tests indicated very little if any change. (The diffusivity is calculated to a standard thickness; the actual diffusion through two boards of equal diffusivity will be less through the board of greater thickness.) The minutes of CK and PS gas protection increased with increasing caliper, possibly due to the increased charcoal loading. The results are too indefinite to show any distinct effect on critical bed.

DISCUSSION

The objective of this work was to determine a board formulation which would provide an optimum balance of physical and chemical properties using pulp obtainable for a commercial operation. However, due to the poor performance of all the boards in terms of sizing and gas life, the effect of the variables under study cannot be accurately evaluated. The effect of the pulp on gas life was unexpected since good results had been obtained consistently with a supposedly identical pulp one year ago (pilot run at Bauer Bros. Company). Increased levels of either Aquapel or Kymene show improved strength and water absorption, especially

TABLE VI

EFFECT OF CALIPER ON DIFFUSION BOARD PROPERTIES
(All boards sized unless noted otherwise)

Sample 2256-2085-	Ovendry Pulp Per Board, lb.	Caliper, in.	Density, lb./cu.ft.	Carbon Dioxide Diffusivity, $sq.cm./sec.x10^{-2}$	Charcoal Loading g./100 sq.cm.	CK Gas Life		PS Gas Life, min.
						min.	Critical Bed, g./100 sq.cm.	
30-1,2	0.700(Unsized)	0.363	19.24	2.93	5.69	13	5.20	22
34-1,2[a]	0.700(Unsized)	0.308	19.56	3.48	4.90	26	3.92	24
32-1,2,3	0.700	0.349	19.42		5.51	7	5.25	19
35-1,2	0.800	0.358	19.80	2.99	5.66	19	4.94	26
35-3,4	0.900	0.404	19.66	3.03	6.35	24	5.44	26

[a] See notation "a" Table IV.

with the Kymene. Previous work had shown a decreased gas life with such increases. The low level of gas life and the comparatively poor sizing and strength of the boards with the "standard" sizing make the present results of questionable value. In terms of properties other than sizing and gas life there does not seem to be any particular advantage in deviating to any extent from the 3/8-in. caliper board formulated with 25% charcoal, 0.5% Aquapel 360 (active), and 0.2% Kymene 557 (active) based on ovendry fiber that had evolved from the work previous to this phase. However, there seems to be some latitude for variations, which might be desirable under some conditions, without seriously hampering the over-all board properties. The zinc oxide did not seem to improve the gas life of the board; however, the indication from earlier work that it does contribute to the stability of the board under tropical aging conditions should not be forgotten.

PREPARATION FOR PRODUCTION RUN

The extension of the contract calls for two production runs on full-scale commercial equipment. Inquiries for possible co-operation in these runs had been addressed to a number of companies and three had indicated interest. Of these, Wood Conversion Company has been chosen because of previous experience with their pulp, geographical proximity, and an apparent greater flexibility in the choice of refining and washing. They have available for pilot use a full-scale machine (No. 2) which is no longer used in commercial production, and had indicated a desire to precede the production run with a trial on this "pilot" machine in order to obtain some familiarity with the handling characteristics of the formulation involved; their cost estimate including this pilot trial was no greater than other cost estimates received. Scheduling of both pilot and production trials must take into account the availability of the particular machine to

be used, but also the availability of related refining equipment. This refining equipment is available only when No. 3 machine is running on mineral fiberboard. Based on all these factors, a pilot trial was scheduled for April 17 with a production run scheduled tentatively for May 7.

During the discussion prior to this trial it was discovered that the 1962 pulp samples used in the laboratory board studies had been taken with less washing and dewatering than on the samples used previously (see discussion under Pulp). Consequently, a request was made in this trial to use fresh water for preparation of the stock and to wash as completely as possible. It was found that a washer could not be used on No. 2 machine on such short notice and that the only method available for washing without delaying the trial was to circulate the stock over the machine and then back into the same machine chest, discarding the white water and replacing it by fresh water.

The pulp was prepared the day before the trial using fresh water. It was refined to a Wood Conversion mill freeness of 400 cc. to allow for some increase in freeness on standing in order to approach the 450-cc. mill freeness which had been suggested. The stock was washed by pumping the stock over the machine and back into the chest--this gives good dewatering but it is not possible to separate the washed and unwashed stock; consequently, the effectiveness decreases with time. Stock was started over the machine at approximately 9:45 a.m. and run for 45 minutes at an estimated rate of 46 pounds per minute. A sample of stock from the grinder chest before washing showed a pH of 4.8, which the operator said would be typical for stock made up with fresh water (water pH normally about 7.0) and represents the acidity in the cooked wood. White water from this washing step was discarded to the sewer and the thickened stock was dropped

to the machine chest and diluted again with hot fresh water. A sample of this stock after the addition of Aquapel and Kymene but without the charcoal showed a pH of 7.0.

The charcoal drums carried the designation ASC, MIL-C-13724, Lot NY-5181-5. The charcoal was weighed out and dispersed in water with a Lightnin' mixer to a slurry having a concentration of 3 pounds of charcoal per gallon. Some difficulty was experienced in getting a good dispersion because of the high concentration and the lack of adequate power on the mixer. However, it was finally dispersed and apparently operated satisfactorily at this concentration once the dispersion was accomplished. A Moyno pump was then adjusted for a delivery rate of 4 g.p.m. corresponding to an addition of 12 pounds of charcoal per minute.

The Aquapel 360 was marked as having been manufactured on April 2, 1969 (?) and carried an illegible lot number. (The invoice carried the code 1-695-604-120.) The Kymene 557 had a lot number M2DTA and a manufacture date of April 2, 1962. (The invoice carried the code 1-595-615-501.) Consistency tests made on the stock in the machine chest showed that the chest contained approximately 2400 pounds of stock. There was some increase in freeness during the washing operation although not as great as the mill personnel thought might occur. There was some reluctance to wash too long because of the danger of losing all the strength. Apparently, it is normal practice to run the stock from the cooker to the machine with little or no removal of any soluble material. An addition of 0.5% Aquapel (active) was calculated to be 12 pounds, which at 6% active material would require an addition of 200 lb. of emulsion. This was weighed out and added slowly to the machine chest (which had good agitation). Kymene was calculated at 0.2% on the fiber, corresponding to an addition at 10% active material of 48 lb. of Kymene 557; this was

weighed out and added to the machine chest. Final addition of these materials was completed about 12:20 p.m. and the stock started over the wire at approximately 12:35 p.m. After getting an approximate adjustment of stock flow to the machine, the charcoal addition was started (12:40 p.m.) and the run continued for 20 minutes. The total production run into the drier consisted of 14 boards 16 feet long and 8 feet wide.

The drying facilities are somewhat limited. They consist of one 60-foot section of a seven dŭsk Coe hot-air drier using steam coils to heat the air. The boards were placed in the drier and left there rather than progressing continuously through the drier as is done in a production drier with more capacity. The maximum temperature of the air in the drier was set at 350°F. At about 2:00 p.m., a fire was discovered; consequently, a number of boards were spoiled by the fire and the water used to extinguish it. The boards did not flame but did glow readily. According to the air temperature chart on the drier, the temperature had risen to 350°F. only 10 to 15 minutes before the fire started. This fire originated, however, in the samples of board which had entered the drier last and presumably had the highest moisture content. Samples of the other boards were run out of the drier and found to be incompletely dried. Accordingly, the maximum air temperature was reduced to 300°F. and the boards were returned to the drier. About 3:30 p.m. another fire was discovered near the center of the drier. As the boards were removed from the drier it was noted that the fire seemed to be on the leading edges of the boards. The boards seemed dry; consequently, the fires were extinguished without water and saved as samples.

Portions of these boards were sent to the Army Chemical Center and to the Institute for testing. The only results available at the end of this reporting

period are for CK gas life tests (Table VII). These CK lives are very low, possibly due to the condition of the pulp and possibly due to the conditions encountered in the drier.

TABLE VII

CK GAS LIVES OF PILOT TRIAL BOARDS

Board No. (order of production)	CK Life, min.
4	3.1
5	2.7
6	3.3
7	4.2

Pulp samples were obtained prior to washing, after 20 minutes of washing and after approximately 45 minutes of washing. A sample of the grinder chest liquor was obtained and a white water sample was obtained after 20 minutes of washing. The pH of the grinder chest liquor was 4.92 and the pH of the white water was 6.04. Hot water solubility and ash tests were initiated on the pulp samples and boards were formed from these samples in the laboratory for gas life tests.

The drier originally used on No. 2 machine and the one available for the planned production trial on No. 1 machine are typical of those used in the industry. The drier on No. 2 now consists of only one section of the original drier and consequently has too little capacity to be used continuously. Fires in such driers are far from unknown; however, the nature of the fires in this run and the recurrence after lowering the air temperature caused Wood Conversion Company personnel to postpone scheduling of a production run until further information is obtained.

DRYING STUDIES

The fires that occurred during the drying phase of the pilot run at the Wood Conversion Company prompted another more critical look at the effects of drying at temperatures in excess of 300°F. Previous studies (Report 9) have been made using dry boards on the premise that once the internal temperature of a single board became equilibrated to the oven temperature the board would either begin to burn or it would not. No consideration was given in those studies to the effects of drying rates, the effect of external temperature on stacks of boards or the effects of extended exposure to temperatures in the range of 300 to 350°F.

Two studies were made during this reporting period using unsized blank boards (Samples 2085-30-1 and 34-1) from the laboratory work described in this report. The boards were cut into sections and stacked three layers thick in a Precision circulating air oven. Thermocouples were inserted into the stacks and connected to a Speedomax six-point temperature recorder.

The first study was made at an oven temperature of 350°F. with minimum air circulation. The previously dried board specimens were soaked for 10 minutes before being placed in the oven. A thermocouple was placed at the bottom of the stack (between an expanded metal shelf and the stack), between the first and second layers, and between the second and third layers. After 2 hours and 16 minutes of exposure, the temperature between the first and second layers was 535°F. the temperature between the second and third layers was 416°F. and the temperature at the bottom of the stack was 350°F. The board was removed from the oven at this time and found to be burning and somewhat charred. The temperature between the layers had risen steadily from a temperature of 180°F. reached after one hour of exposure to the final temperature.

The second study was made at an oven temperature of 300°F. with minimum air circulation. The board specimens were soaked for 16 hours before being stacked in the oven. Thermocouples were placed at the bottom of the stack, between the first and second layers, in the second layer, and between the second and third layers. The stack temperatures equalled the oven temperature after 6 hours of exposure. The temperature of the bottom of the stack rose steadily while the internal temperatures approached and remained at a temperature of 150°F. during the first 2 hours of exposure; the temperatures between the layers began to rise somewhat erratically while the internal temperature remained at 150°F. for an additional 1 hour and 20 minutes before rising to the oven temperature. After 8 hours and 46 minutes of exposure the stack temperatures were still 300°F. and the test was halted.

These results infer that there is a critical temperature between 300 and 350°F. where ignition will take place. Further studies are intended using stacks and single layers of freshly made board in the range of 300 to 350°F.

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